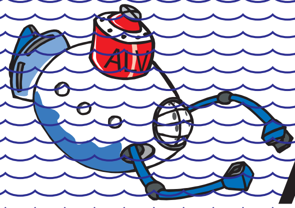

An Underwater Sediment Slide?

Focus
Sediment transport

Grade Level
7 - 9

Focus Question
Can an underwater canyon act as a giant slide for sediments and pollutants?

Learning Objectives
Students will learn about the proximity of the Hudson Shelf Valley and the Hudson Canyon to one of the Nation's most populated areas.

Students will learn that from 1987 to 1992, two dumpsites in the Hudson Shelf Valley and Hudson Canyon, one 12 miles out to sea and one 106 miles out to sea, were used to dispose of sewage.

Students will learn that canyons transport contaminants from nearshore areas to the deep sea.

Materials
For the teacher:

- ❒ Overhead map of the Hudson Shelf Valley and Hudson Canyon – attached (http://woodshole.er.usgs.gov/project-pages/newyork/ or http://pubs.usgs.gov/factsheet/fs114-99/fs114-99.html
- ❒ Five cardboard poster tubes or wrapping paper tubes (of larger diameter), approximately 3 feet long
- ❒ Scissors
- ❒ Aquarium or another clear container that can hold water
- ❒ Water – enough to fill the aquarium or clear container to a water depth of 4-6 inches
- ❒ 1 cup of sand
- ❒ A paper cup (large enough to hold 1/4 cup of sand)
- ❒ A funnel
- ❒ Colored tablets or beads that dissolve readily in water (Easter egg dye tablets, pieces of and Alka-Seltzer tablet, bath toy beads for kids that fizz and change bath water color)

Per four students:

- ❒ One-half of a cardboard poster tube that has been cut in half lengthwise
- ❒ 1 cup of sand (they will use 1/4 cup 4 times)
- ❒ A paper cup (large enough to hold 1/4 cup of sand)
- ❒ A funnel
- ❒ A stopwatch
- ❒ A large sheet of paper, at least 30 inches wide by 36 inches long (butcher paper or bulletin board paper works well)
- ❒ A pencil
- ❒ A yardstick or ruler

Audio/Visual Equipment
Overhead projector

Teaching Time
One hour

Seating Arrangement
In groups of four

Maximum Number of Students
36

Kew Words

Contaminant
Sediment
Sewage
Transport

Background Information

The following background information has been taken, with permission, from the following USGS publication: *Contaminants and Marine Geology in the New York Bight: Modern Sediment Dynamics and a Legacy for the Future*. This document was written by Ellen L. Mecray, Marilyn Buchholtz ten Brink, and Bradford Butman of the U.S. Geological Survey at Woods Hole Field Center. This publication is available at the following website address: http://marine.usgs.gov/

The Impact of Human Activity in the New York Bight

The New York-New Jersey metropolitan area is one of the most populated and polluted coastal regions in the United States (fig. 1). The area offshore of New York is used for waste disposal, transportation, recreation, and commercial and recreational fishing. The largest deposit of sewage sludge in the country has been dumped in the apex of the New York Bight (125 million cubic meters over 64 years) (fig. 2). Harbor dredge spoils that are contaminated with heavy metals and organic pollutants also have been disposed of in the area, while additional wastes are carried directly from land by regional currents. Materials from diverse sources have added large amounts of metals, carbon, bacteria, and organic contaminants to the sea floor over the last century. These materials have been dispersed and diluted over time; however, sediments have become polluted as a result of these activities. Enforcement of environmental legislation and reduced use of the oceans for waste disposal have resulted in fewer sources of pollutants to coastal sediments in recent years.

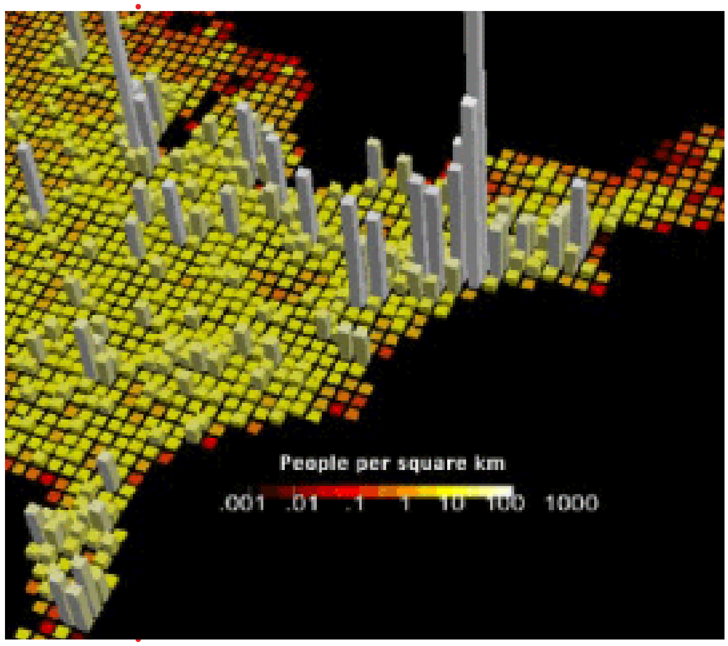

Figure 1. Population density of the eastern United States. Polluted sediments occur in the coastal ocean near major population centers. Fifty percent of the U.S. population lives within 50 miles of the coasts; about 80% within 200 miles. The New York-New Jersey region is one of the largest population centers.

The U.S. Geological Survey's Coastal and Marine Geology Program is conducting a long-term multidisciplinary study in the New York-New Jersey region to characterize the sediments on the sea floor, map the distribution of

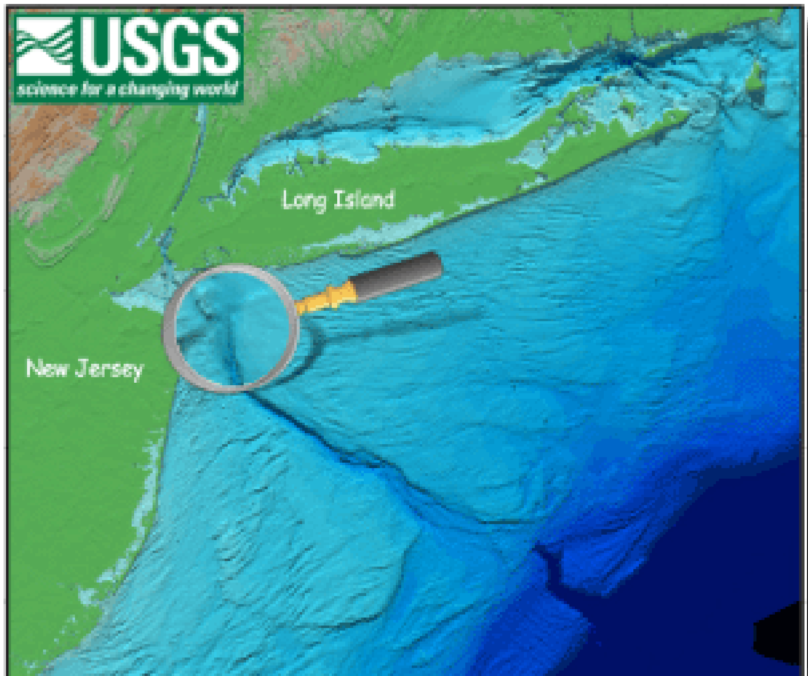

Figure 2. Bathymetry of the coastal ocean in the New York-New Jersey metropolitan region. The sandy, relatively shallow mid-Atlantic continental shelf is bisected by the Hudson Shelf valley, a submerged river valley containing muddy sediments that may act as a conduit for cross-shelf transfer of sediments.

contaminants in the sediments, and develop a predictive model for the long-term transport and fate of sediments and contaminants. This regional understanding of the sea-floor geology and dynamics of these coastal sediments is needed by Federal, State, and local agencies for management and use of the coastal ocean, and by scientists to plan and conduct research and monitoring.

Mapping the Sea-floor and Its Contaminants

Mapping of the sea-floor geology in the New York-New Jersey metropolitan region provides an overall synthesis of the sea-floor environment, including sediment texture, topography, and the effects of human activity. Data collected from each survey consist of sidescan sonar mosaics, high-resolution seismic profiles, sediment samples, and bottom photography. The resulting maps of the sea floor show changes in the bottom character and sediment texture and the effects of human activity.

The distribution of contaminants in sediments and changes in their patterns observed over time have been used to identify dispersal and deposition patterns, transport rates, and to ascertain the potential of the affected sediments for inducing toxic effects in biota. Chemical and physical analyses of sediment samples were combined with seismic data to provide a three-dimensional assessment of contaminant distribution in the region. Many contaminants adhere to particles and move with the sediments in the marine environment. The distribution patterns measured for one particle-reactive contaminant are often similar to those of another contaminant that has similar sources. Consequently, areas where lead concentrations are high also have high concentrations and inventories of many other pollutants.

Metal and bacterial contaminants measured in sediment samples indicate widespread pollution on the broad, sandy shelf and in the muddy sediments of the Hudson Shelf valley. The highest concentrations occur in muddy deposits near dump sites and in the northern basins of the upper Hudson Shelf valley. More than 10 percent of the sewage sludge dumped is found in the upper valley. Metal concentrations show that sediment is migrating away from the dump sites as far as 80 km down the valley. These pools of pollutants are an ongoing source of contaminants and carbon to the New York Bight. Monitoring the sediment record over time shows decreasing concentrations of contaminants in sediments near the disposal sites. This decrease is a result of improvements in disposal practices and removal of the finer sediments from the sandy shelf by winnowing. Despite disposal regulations and the cessation of dumping, the data suggest that sediments are continually redistributed by currents and biological processes. Mixing in the sediments allows contaminated material to be accessible to benthic organisms.

The National Oceanic and Atmospheric Administration Hudson Canyon Cruise

During the cruise in the Hudson Shelf Valley and Hudson Canyon, scientists will be studying how effective the Hudson Shelf-Valley Canyon system is as a conduit for sediment and contaminant transport from nearshore areas to the deeper waters offshore. As you can see from the bathymetry of the area, the canyon is like a giant underwater slide or ski slope; it makes sense that this geologic feature would serve as a slide or ski slope for sediments and pollutants.

The three questions that scientists will be trying to answer during the cruise follow:

1. How much have concentration of sludge-derived contaminants been changed by natural processes since sludge dumping ceased?
2. Is there evidence for continued lateral transport of deposited sludge indicators in the direction of the bottom current flow?
3. How effective is the Hudson Shelf Valley-Hudson Canyon system as a conduit for transporting contaminants and organic carbon from nearshore areas to the deep sea?

Scientists may use the following methods to characterize the distribution, transport and fate of sediment-bound contaminants:

1. Use of high-resolution seafloor maps to identify potential sediment transport paths and areas of fine-grained sand accumulation,
2. Collecting the upper 10-70 cm of sediment using corers,
3. Collecting the easily remobilized sediment "fluff" with a filtration device,
4. Recording the sedimentary and benthic environment with bottom video or photography,
5. Analyzing the sediment samples for chemical indicators of contamination,
6. Analyzing the sediment and videos for grain size and sediment type (i.e., would sediments of this type and size typically be found at this depth?),
7. Mapping the distribution of contaminants, bacterial sewage tracers, and sediment type, and
8. Quantifying the accumulation rates of sediments and contaminants at specific study

sites.

Sample collection techniques will vary based on the operational depth of the equipment and sample precision required for specific study sites. Sampling methods may include using a manned submersible, a remotely-operated vehicle, the United States Geological Survey hydraulically-damped gravity corer, and box corer.

Sediments will be analyzed for a suite of 40 elements using inductively coupled plasma (ICP) emission spectrometry and mass spectrometry. A subset of samples will be analyzed for organic contaminants and sewage tracers.

Learning Procedure

Prior to the lesson:

- Cut five poster tubes in half lengthwise.
- Fill aquarium with four to six inches of water.
- Mix colored tablets with cup of sand

The day of the lesson:

1. Show students the location of the Hudson Shelf Valley and Hudson Canyon in relation to the big cities of New York and New Jersey.
2. Tell students about the sewage that was dumped into the ocean from 1987 to 1992.
3. Tell students that they will be working in groups of four to conduct an experiment on sand transport.
4. Provide groups with materials and ask them to find floor space to conduct their experiment. Each group will need space to roll out a three-foot long sheet of paper.
5. Ask one student to be a sand pourer, one to be an observer, one to be a timer and the other to be a recorder.
6. At this point, provide an overview of what students will be doing. Demonstrate, if needed.
7. Tell teams to roll out their paper so that the shortest edge is closest to them.
8. Ask the recorder to draw a “starting line” about two inches from the shortest edge of the paper.
9. Ask the observer to place one end of the tube (now referred to as the bottom end) on the starting line with the curved side of the tube facing upwards.
10. Ask the observer to hold the top of the tube six inches off of the ground, making sure that the bottom edge of the tube is still sitting on the starting line.
11. Ask the sand pourer to pour sand through a funnel onto the top end of the cardboard tube.
12. Ask the timer to use a stopwatch to measure how much time elapses from the time the sand first hits the top of the tube until the sand first hits the starting line on the paper.
13. Ask the recorder to outline on the paper how far the sand traveled once it hit the paper and to note where sand is deposited thickly and thinly.
14. Ask the recorder to label the sand outline as “six inches high”.
15. Ask students to repeat steps 9 through 14 listed above three more times; once with the top of the tube 12 inches off the ground, once with the top of the tube at 18 inches from the ground, and a final

time with the tube held 24 inches off the ground. Tell the sand pourer to pour the sand at the same rate each time.

16. Note that when the top of the tube is held six inches above the ground, most sand will stop moving somewhere along the length of the tube. Ask the recorder to note this.
17. Discuss results. When the tube was held higher off the ground, did the sand travel faster? Farther?
18. Place aquarium at the front of the classroom where all students can see the water.
19. Tell students that the top of the tube is located in shallow water (or on land) and that the bottom of the tube in located in deeper water.
20. Tell students that the sand you are about to pour into the tube contains contaminants.
21. Place the bottom of the tube just over the top of the water in the aquarium.
22. Tell students to watch the water in the aquarium.
23. Pour sand through the funnel and onto the top of the tube. Hold the tube at about a 45-degree angle.
24. The sand should settle at the bottom of the aquarium (this may take several moments), but the colored tablets should rapidly begin to dissolve/color the water.
25. Ask students, based on their observations, if they believe an underwater submarine canyon might serve as a way for pollutants to reach deeper water.

The BRIDGE Connection

Visit the BRIDGE website at http://www.vims.edu/bridge/. Under the Navigation toolbar click on Marine Geology and then Ocean Planet: Sea Secrets to access more activities on ocean pollution.

The "ME" Connection

How might some of the things the people in a town or city do impact people that live downstream from them? What concerns might you have if you found out that a nuclear power plant or chemical factory were being placed in the watershed in which you live? If you do not know what a watershed is, visit the South Carolina Aquarium's Web-based curriculum for 6th-8th graders to find out! www.scaquarium.org

Connections to Other Subjects

Geography – Use a topographic map that shows ocean seafloor to identify underwater canyons and other areas around the world. Identify those located near highly populated areas on land.

Evaluation

Gauge student understanding using the student responses to the question posed in step number 25 in the learning procedure outlined above.

Extensions

Contact scientists during the upcoming Hudson Shelf Valley and Hudson Canyon Expedition to find out what they are learning about the canyon and how effective it is at transporting sediments and pollutants to deep water.

Resourcees

Websites for student research
http://www.mbari.org/
http://www.ngdc.noaa.gov/mgg/
http://www.whoi.edu/science/science.html

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Motions and forces

Content Standard D: Earth and Space Science

- Structure of the Earth system

Content Standard E: Science and Technology

- Understandings about science and technology

Activity developed by Stacia Fletcher, South Carolina Aquarium, Charleston, SC

Hudson Shelf Valley and Hudson Canyon